COMANDO DA AERONÁUTICA

CENTRO DE INVESTIGAÇÃO E PREVENÇÃO DE ACIDENTES AERONÁUTICOS

FINAL REPORT
IG - 048/CENIPA/2017

OCCURRENCE:	**SERIOUS INCIDENT**
AIRCRAFT:	**PP-PTQ**
MODEL:	**ATR-72-212A**
DATE:	**23MAR2017**

NOTICE

According to the Law nº 7565, dated 19 December 1986, the Aeronautical Accident Investigation and Prevention System – SIPAER – is responsible for the planning, guidance, coordination and execution of the activities of investigation and prevention of aeronautical accidents.

The elaboration of this Final Report was conducted taking into account the contributing factors and hypotheses raised. The report is, therefore, a technical document which reflects the result obtained by SIPAER regarding the circumstances that contributed or may have contributed to triggering this occurrence.

The document does not focus on quantifying the degree of contribution of the different factors, including the individual, psychosocial or organizational variables that conditioned the human performance and interacted to create a scenario favorable to the accident.

The exclusive objective of this work is to recommend the study and the adoption of provisions of preventative nature, and the decision as to whether they should be applied belongs to the President, Director, Chief or the one corresponding to the highest level in the hierarchy of the organization to which they are being forwarded.

This Report does not resort to any proof production procedure for the determination of civil or criminal liability, and is in accordance with Appendix 2, Annex 13 to the 1944 Chicago Convention, which was incorporated in the Brazilian legal system by virtue of the Decree nº 21713, dated 27 August 1946.

Thus, it is worth highlighting the importance of protecting the persons who provide information regarding an aeronautical accident. The utilization of this report for punitive purposes maculates the principle of "non-self-incrimination" derived from the "right to remain silent" sheltered by the Federal Constitution.

Consequently, the use of this report for any purpose other than that of preventing future accidents, may induce to erroneous interpretations and conclusions.

N.B.: This English version of the report has been written and published by the CENIPA with the intention of making it easier to be read by English speaking people. Taking into account the nuances of a foreign language, no matter how accurate this translation may be, readers are advised that the original Portuguese version is the work of reference.

SYNOPSIS

This is the Final Report of the 23MAR2017 serious incident with the ATR-72-212A aircraft model, registration PP-PTQ. The accident was classified as “[SCF-NP] System/Component Failure or Malfunction Non-Powerplant – With Flight Commands”.

During the descent for landing at the André Franco Montoro Aerodrome (SBGR), Guarulhos - SP, while performing the Instrument Landing System (ILS) procedure, with the Autopilot (PA) engaged, the aircraft tended to continue the left turn.

The crewmembers decoupled the autopilot and noticed that the tendency to the left continued during the approach.

The crewmembers carried out a go-around procedure and made a traffic circuit for visual landing, with turns to the right, without the aid of the autopilot.

The landing took place on the SBGR RWY 09R.

The aircraft had minor damage.

All the occupants left unharmed.

An Accredited Representative of the National Transportation Safety Board (NTSB) - USA, (State where the components of the aircraft's autopilot system were manufactured) and an Accredited Representative of the Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile (BEA) – France, (State where the aircraft was designed) were designated for participation in the investigation.

CONTENTS

GLOSSARY OF TECHNICAL TERMS AND ABBREVIATIONS

AMM	Aircraft Maintenance Manual
AMR	DCTA's Material Division of the Aeronautics Space Institute
ANAC	Brazil's National Civil Aviation Agency
BEA	Bureau d'Enquêtes et d'Analyses pour la Sécurité de l'Aviation Civile
CA	Airworthiness Certificate
CB	Circuit Breaker
CENIPA	Aeronautical Accident Investigation and Prevention Center
CMA	Aeronautical Medical Certificate
CMM	Component Maintenance Manual
CVR	Cockpit Voice Recorder
DCTA	Department of Science and Airspace Technology
MPD	Maintenance Planning Document
FDR	Flight Data Recorder
IFR	Instrument Flight Rules
IFRA	Instrument Flight Rating - Helicopter
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
IAE	Aeronautics Space Institute
ISC	Industry Steering Committee
METAR	Aviation Routine Weather Report
MEV	Scanning Electron Microscope
MRB	Maintenance Review Board
MRBR	Maintenance Review Board Report
MSG	Maintenance Steering Group
NTSB	National Transportation Safety Board
PA	Auto Pilot
PCM	Commercial Pilot License - Airplane
PLA	Airline Pilot License - Airplane
PN	Part Number
PPR	Private Pilot License - Airplane
SBGR	ICAO Location Designator - Governador André Franco Montoro International Airport, Guarulhos - SP
SBRP	ICAO Location Designator - Leite Lopes Aerodrome, Ribeirão Preto - SP
SN	Serial Number
SPECI	Selected Special Aeronautical Weather Report
TPR	Aircraft Registration Category of Regular Public Transport
UTC	Universal Time Coordinated

VMC	Visual Meteorological Conditions

1. FACTUAL INFORMATION.

Aircraft	**Model:** ATR-72-212A **Registration:** PP-PTQ **Manufacturer:** ATR-GIE *Avions de Transport Régional*	**Operator:** *Passaredo Transportes Aéreos S.A*
Occurrence	**Date/time:** 23MAR2017 - 0135 UTC **Location:** *Governador André Franco Montoro* International Airport (SBGR) **Lat.** 23°26’08”S **Long.** 046°28’23”W **Municipality – State:** Guarulhos – SP	**Type(s):** “[SCF-NP] System/Component Failure or Malfunction Non-Powerplant” **Subtype(s):** With Flight Commands

1.1 History of the flight.

The aircraft took off from the Leite Lopes Aerodrome (SBRP), Ribeirão Preto - SP, to the Governor André Franco Montoro International Aerodrome (SBGR), Guarulhos - SP, at about 0020 (UTC), in order to transport personnel, with four crewmembers and 55 passengers on board.

During the ILS T procedure of SBGR runway 09R, at 4,300ft, there was a tendency for the aircraft to continue the left turn, when intercepting the locator with the autopilot engaged.

The crew decoupled the PA, however, the aircraft's tendency to turn left continued, which led to a lateral lag in relation to the locator's axis and the execution of a go around.

The crewmembers executed a traffic circuit for visual landing with turns to the right. The flight crew tried to reengage the autopilot five times, the autopilot was disconnecting hence the approach was continued with autopilot off. Landing was carried out on runway 09R of SBGR.

The aircraft had minor damage.

All occupants left unharmed.

1.2 Injuries to persons.

Injuries	Crew	Passengers	Others
Fatal	-	-	-
Serious	-	-	-
Minor	-	-	-
None	4	55	-

1.3 Damage to the aircraft.

The aircraft had limited damage to the Servo Drive of the aileron command through the autopilot and one of its cables.

1.4 Other damage.

None.

1.5 Personnel information.

1.5.1 Crew's flight experience.

Flight Hours		
	Pilot	Copilot
Total	14.856:30	2.456:15
Total in the last 30 days	59:35	59:35
Total in the last 24 hours	04:45	04:45
In this type of aircraft	6.250:35	857:30
In this type in the last 30 days	59:35	59:35
In this type in the last 24 hours	04:45	04:45

N.B.: The data related to the flown hours were obtained through the records given by the aircraft operator.

1.5.2 Personnel training.

The pilot took the PPR course at the Jaboticabal Aeroclub – SP, in 1982.

The copilot took the PPR course at the São Paulo Aeroclub – SP, in 2009.

1.5.3 Category of licenses and validity of certificates.

The pilot had the PLA License and had valid AT47 aircraft type Rating (which included the ATR-72-212A model) and IFRA Rating.

The copilot had the PCM License and had valid AT47 aircraft type Rating and IFRA Rating.

1.5.4 Qualification and flight experience.

The pilots were qualified and had experience in the kind of flight.

1.5.5 Validity of medical certificate.

The pilots had valid CMAs.

1.6 Aircraft information.

The aircraft, serial number 874, was manufactured by ATR - GIE *Avions de Transport Régional*, in 2009 and it was registered in the TPR category.

The aircraft had valid Airworthiness Certificate (CA).

The technical maintenance records were updated.

The last inspection of the aircraft, the "800FH" type was carried out on 11JAN2017 by the maintenance organization *Base de Manutenção Passaredo*, in Ribeirão Preto - SP, with the aircraft having flown 744 hours after the overhaul.

There was a major scheduled maintenance intervention on the aircraft, called by the manufacturer as "Inspection 2C", which took place on 15MAY2016.

The last scheduled maintenance, according to annual calendar criteria, called by the manufacturer as "Inspection 1YE", occurred on 24JUL2016.

At the time of the incident, the aircraft had 22,499 hours and 19,218 total operating cycles.

1.7 Meteorological information.

According to the crewmembers, the flight was being conducted under IMC.

The METAR and the SPECI of SBGR brought the following information:

METAR SBGR 220100Z 13004KT 9999 BKN014 19/17 Q1024=

METAR SBGR 220200Z 14005KT 9999 BKN013 BKN030 19/17 Q1023=

SPECI SBGR 220230Z 12006KT 9999 FEW015 BKN030 19/17 Q1024=

It was found that the visibility in SBGR was above 10km and the ceiling was at approximately 1,400ft. The wind had an intensity between 4kt and 5kt.

1.8 Aids to navigation.

Nil.

1.9 Communications.

According to the audio transcripts, obtained through the data transcription recorded by the Cabin Voice Recorder - CVR, there was no technical abnormality in the communication equipment between the aircraft and the ATC.

1.10 Aerodrome information.

The Aerodrome was public / military, managed by GRU Airport and operated under VFR and by IFR, during day and night.

The runway was made of asphalt, with thresholds 09R / 27L, dimensions of 3,000m x 45m, with an elevation of 2,461 feet.

1.11 Flight recorders.

The aircraft was equipped with a FDR, manufactured by L-3, model FA2100, Part Number (PN) 2100-4043-00, Serial Number (SN) 01321.

The plane also had a CVR, manufactured by L-3, model FA2100, PN 2100-1020-02, SN 125977, with capacity for two hours of recording in 4 channels of 30 minutes in high quality and 1 channel of standard quality, with capacity for 2 hours of audio.

Both recorders registered the data related to the flight on which this occurrence happened.

1.12 Wreckage and impact information.

Nil.

1.13 Medical and pathological information.

1.13.1 Medical aspects.

No evidence was found that problems of physiological nature could have affected the flight crew performance.

1.13.2 Ergonomic information.

Nil.

1.13.3 Psychological aspects.

No evidence was found that problems of physiological nature or incapacitation could have affected the flight crew performance.

1.14 Fire.

There was no fire.

1.15 Survival aspects.

After landing, the aircraft taxied normally to the apron area.

The disembarkation of passengers and crewmembers took place without abnormalities.

1.16 Tests and research.

The initial surveys, conducted on the day after the event, focused on the command of the ailerons. It was found that the movement of the control wheel was restricted.

Starting from the neutral position, turning the steering wheel clockwise allowed the ailerons to be controlled throughout their course, up to their stop, and resulted in the expected movement of these surfaces, upwards on the right wing and downwards on the left wing (Figure 1).

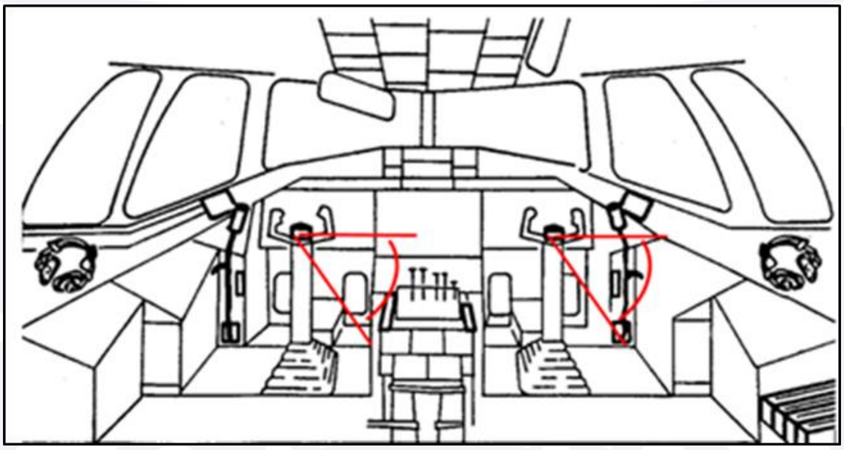

Figure 1 – The approximate amplitude of command clockwise.
Source: ATR.

However, starting from the same position, turning the steering wheel counterclockwise did not allow the ailerons to be controlled throughout their course, since the rotation movement of the control wheel was blocked when the control reached approximately 15° of rotation.

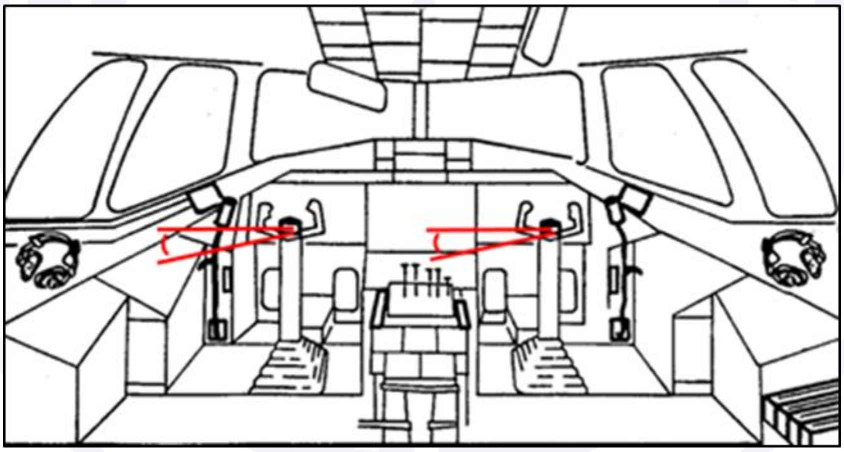

Figure 2 - The approximate amplitude of command counterclockwise.
Source: ATR.

From this observation on, a verification of the ailerons control system started, beginning from the control wheel towards the surfaces, in order to identify the existence of any component (cables, pulleys, bellcranks, rods, actuators and the ailerons themselves) that was causing the restriction on the command.

The control of the aileron through the autopilot, among other elements, took place through the performance of an actuator device called Servo Drive, PN 7002260-722, SN 96115209, which received electrical signals and converted them into rotating movements of a drum, where a control cable was connected. This control cable connected to the aileron command bellcrank.

Figure 3 shows the location of the Servo Drive in the aileron control system. In it, the component is identified as A. P. ROLL ACTUATOR.

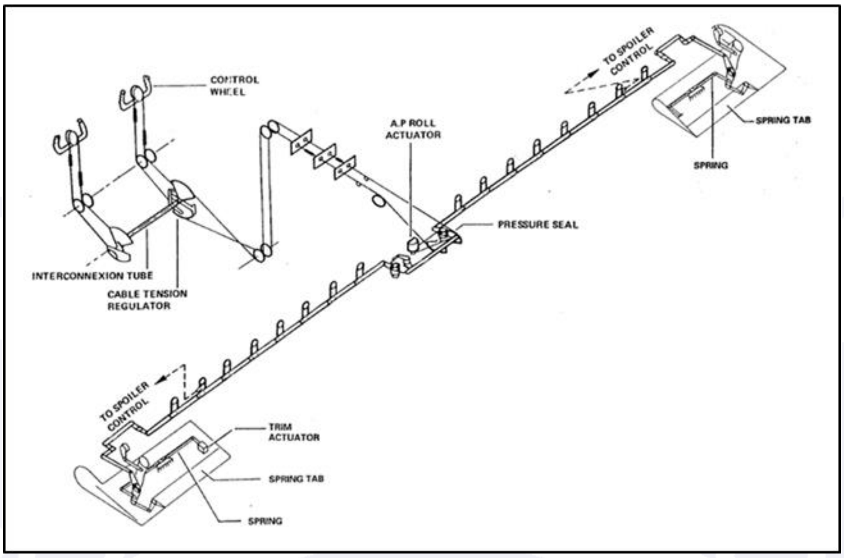

Figure 3 - Schematic of the ailerons control system.
Source: ATR.

Figure 4 shows the location of the Servo Drive on the aircraft (A).

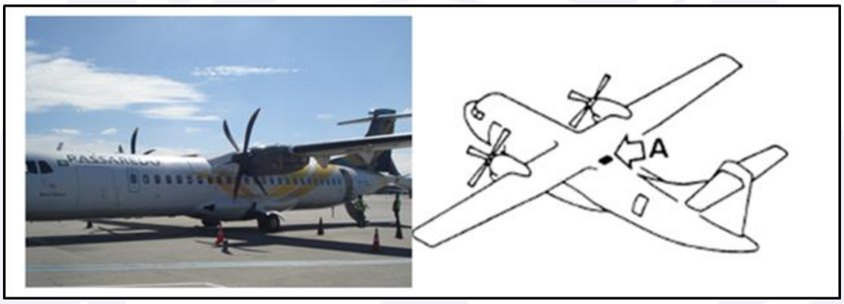

Figure 4 - General view of the aircraft and location of the Servo Drive.

Figure 5 shows the Servo Drive (item 1) connected to the bellcrank, using the PN S2211001100000 control cables.

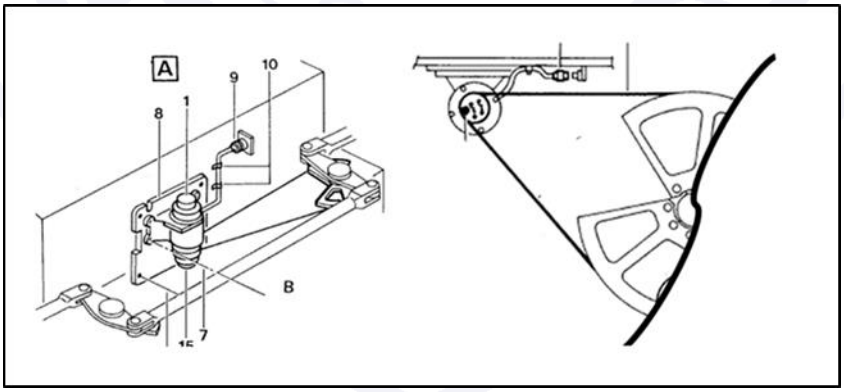

Figure 5 - Servo Drive (item 1) connected to the bellcrank using PN S2211001100000 control cables.
Source: ATR.

The examination of the aircraft showed that one of the control cables PN S2211001100000, which connected the autopilot's Servo Drive to the aileron control bellcranks (Quadrant Assy), was broken.

After removing the Servo Drive from the plane, together with the broken control cable, it was found that the rotating mechanism where the cables were rolled up, called capstan, was blocked and prevented from turning (Figure 6).

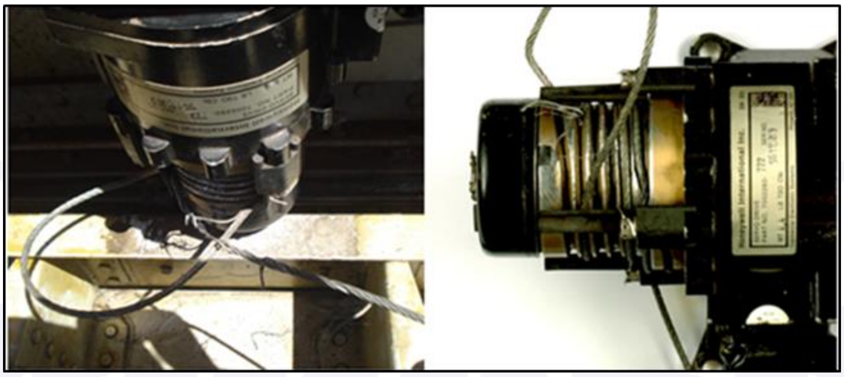

Figure 6 - Servo Drive removed from the aircraft with its cable broken.

The aircraft had two other Servo Drives installed for the operation of the autopilot: one for controlling the rudder and the other for the elevator. It was found that the capstan of these Servo Drives had their free movement when the autopilot was not engaged. In this condition, it was possible to freely rotate the capstan of both Servo Drives, with both hands, in both directions.

It was also verified that the Circuit Breaker (CB), located in the pilot's cabin, responsible for the protection of the electric circuit and for the passage of energy for the operation of the Servo Drives, remained armed (closed).

According to the aircraft manufacturer, the current required for opening the electrical circuit (CB disarm) was of 7.5 amps. The maximum consumption of the Servo Drive, under normal conditions, was of 3.5 amps.

Subsequently, the partial disassembly of the damaged Servo Drive and the analysis of its control cables were carried out at the headquarters of the BEA, with the accompaniment of representatives of the aircraft manufacturer, of the CENIPA and of the DCTA's Material Division of the Aeronautics Space Institute.

The Servo Drive had the following components: an electric engine at one end; a gearbox and a drum, called capstan, in the central body; and, at the opposite end, a mechanism that played the role of clutch. This last device had the function of mechanically connecting and disconnecting the capstan to the electric engine (Figure 7).

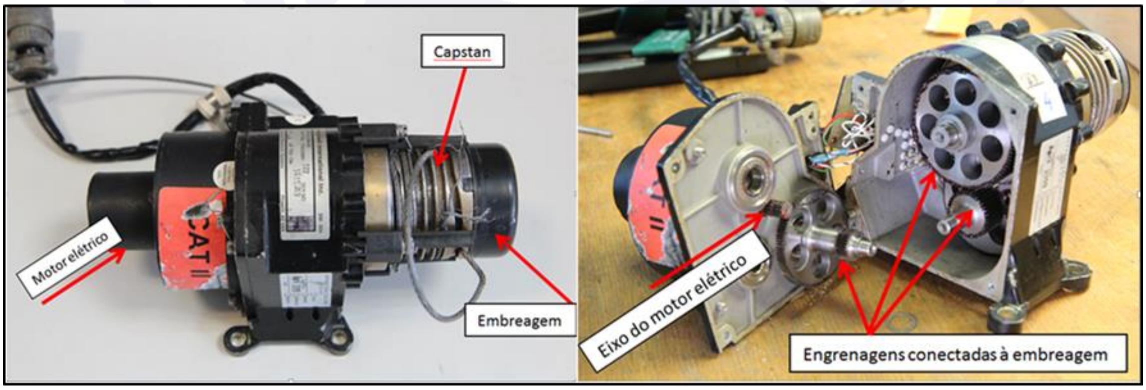

Figure 7 - Details of the Servo Drive components.

The partial disassembly of the Servo Drive showed that, after removing the broken control cable, the capstan could rotate freely. This free-rotation feature of the Servo Drive was what allowed the pilot to act on the flight controls when the autopilot was not engaged.

Thus, it was concluded that the capstan was locked due to the control cable becoming entangled in the drum after breaking. In turn, the restrictions on the aileron command were due to the capstan being blocked by the broken cable.

During the examinations, it was also verified that the front block of the Servo Drive (clutch) could not be turned manually.

After separating the section of the electric engine / gearbox, with the disconnection of its gear set (n° 45, in red in the diagram below), the front block could be rotated without any resistance. However, the electric engine shaft (part n° 5, in blue) showed some resistance to manual rotation. The bearing (n° 70, in yellow) appeared to be in good condition (Figure 8).

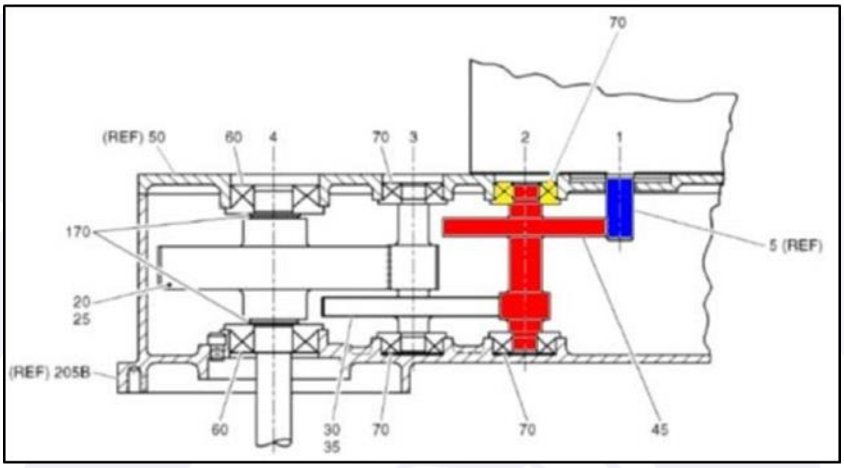

Figure 8 - Identification of the electric engine / gearbox coupling components to the central body of the Servo Drive.

The distances between the four cable keepers and the drum were measured in the position established by Figure 7014 of the Component Maintenance Manual (CMM) (Figure 9).

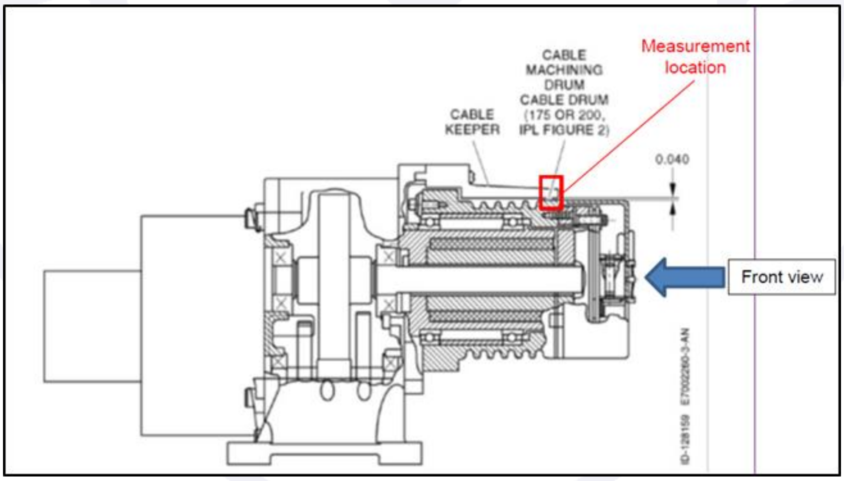

Figure 9 - Cable keepers distance measurement position.

They ranged from 0.95 to 3.10mm (+/- 0.10mm). The CMM required a maximum of 0.040 inches (1.016mm). No wear on the cable keepers was observed with the naked eye at the measurement positions. Wear areas have been identified in other regions, probably due to the friction between the cable keepers and the cables (Figure 10).

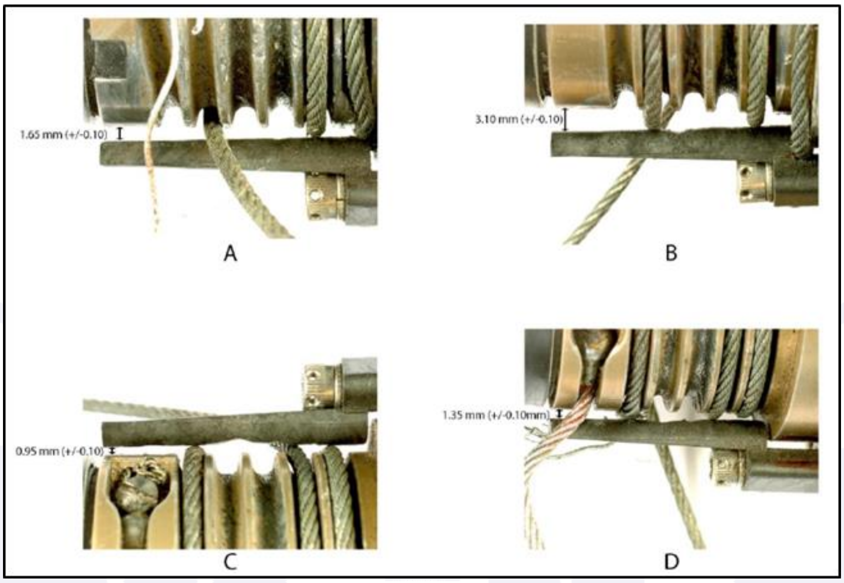

Figure 10 - Details of measurements and wear observed on cable keepers.
Source: BEA.

The control cable PN S2211001100000 is a 7 x 7 construction wire rope. A wire rope of this construction consists of 6 outer strands of 7 wires each laid around a strand core of 7 wires.

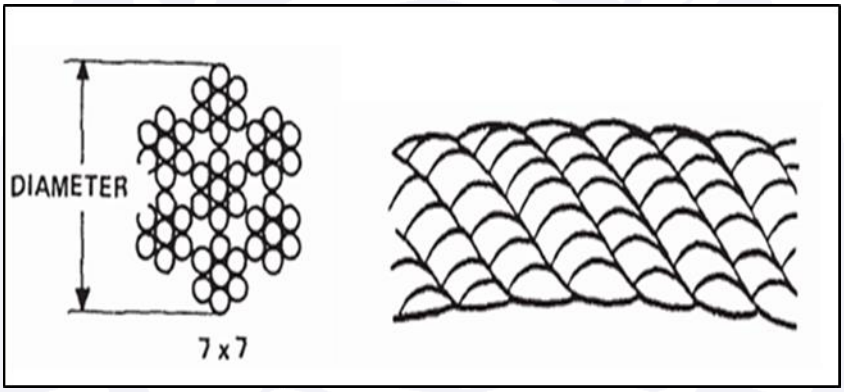

Figure 11 - Drawing of a transversal and lateral section of a cable PN S2211001100000.

The broken control cable was subjected to tests with a Scanning Electron Microscope (SEM) (Figure 12).

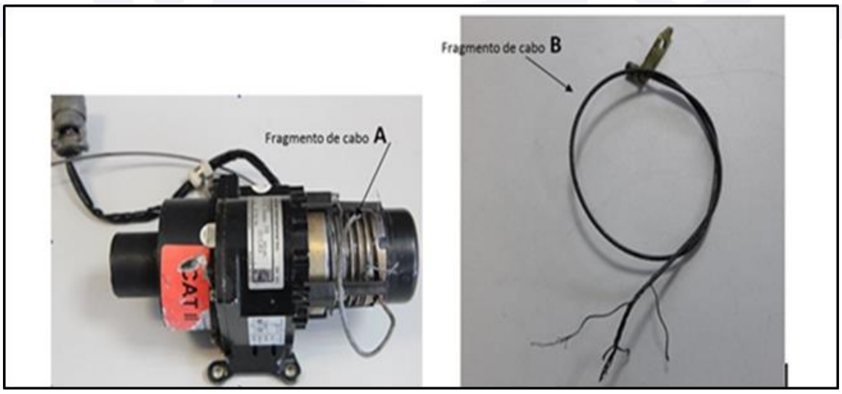

Figure 12 - Cable fragment connected to the Servo Drive (A) and cable fragment that was connected to the bellcrank (B).

The tests carried out showed that there were signs of wear, plastic deformation and ductile fractures, as well as the presence of corrosion on the surface of the cable.

Figure 13 - Enlarged view of control cable wires removed from the Servo Drive with marks of plastic deformation and oxidation on the surface.
Source: BEA

It was also found that a fatigue mechanism had occurred in several fracture regions.

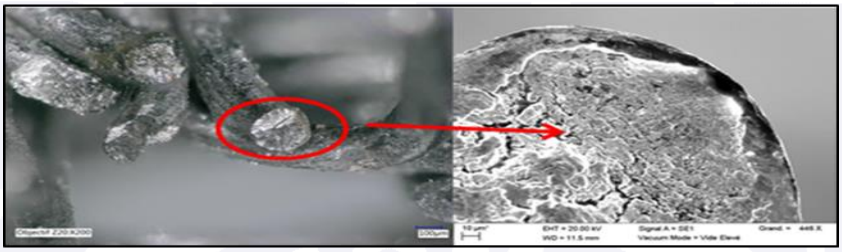

Figure 14 - Fragment of cable A (connected to the Servo Drive). Fractured surface of one of the wires with beach marks, fatigue characteristics of the material.
Source: BEA

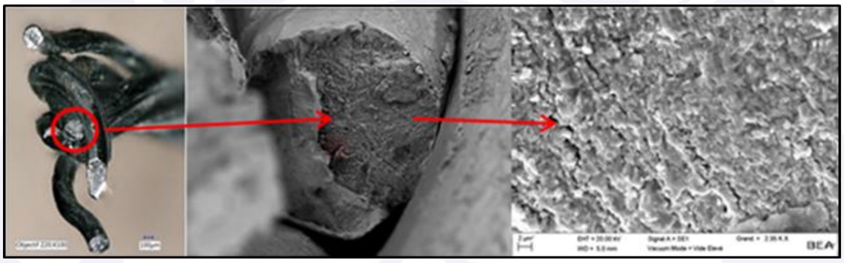

Figure 15 - Fragment of cable A. Fractured surface of another wire, also showing beach marks, characteristics of material fatigue.
Source: BEA

In addition, observations of a cross section under the microscope of the cable showed that several wires had little or no zinc coverage.

Finally, the report issued by the AMR concluded that the cable failure was due to a fatigue process and that plastic deformations and oxidation probably occurred after the rupture.

The Servo Drive and the electric engine that integrated it were also analyzed, later, on the premises of a maintenance organization responsible for the overhaul of that component, following the protocols established in the relevant CMM.

The work took place with the participation of representatives from the CENIPA, the NTSB, Honeywell International Inc. (manufacturer of Servo Drive) and members of the maintenance organization.

The analysis started with the identification of the Servo Drive, followed by a visual check, in order to know the condition in which the part had arrived for the analysis.

Figure 16 - Servo Drive and its identification plates.

Figure 17 - Servo Drive and the identification of the electric engine.

During the visual verification, the following was verified:

- the cable drum, or capstan, was free to rotate.

Figure 18 - Capstan free to rotate in both directions, clockwise and counterclockwise.

- the cable keepers were worn on the part facing the cable drum (capstan).

- most of the wear on the cable keepers was on the inner face associated with the three internal notches (closest to the clutch) of the cable drum (Figure 19).

Figure 19 - Cable keeper positioned and a wear detail.

- the clutch mechanism cover screws were not tightened (they appeared to have been adjusted only with the fingers).

- all the braking wires had been removed: each screw was without the required braking wire.

- after removing the cover from the clutch mechanism, a small amount of debris was found in the capsule itself (Figure 20).

Figure 20 - Cover without the braking on the screws and detail of the debris.

- the clutch was disengaged (Figure 21).

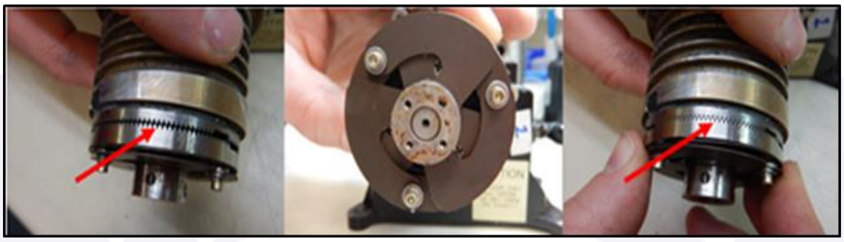

Figure 21 - Clutch disengaged, front view and manually engaged.

- the quality control seal on the underside, located between the engine cover and the gears train, was broken (Figure 22).

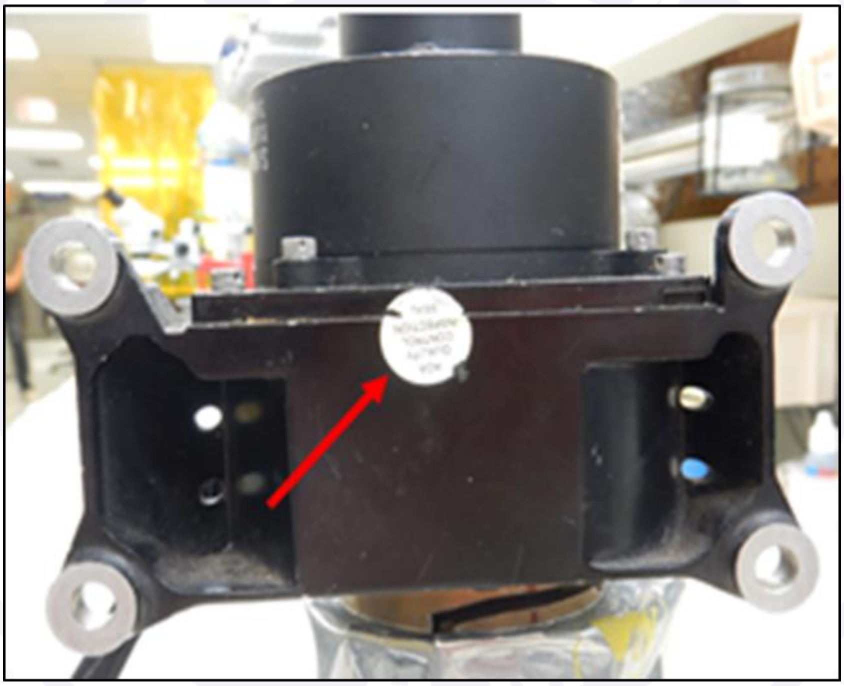

Figure 22 - Quality control seal broken.

- the four cable keepers, the cable keepers screws and the washers had been removed and were found in a plastic bag, which was in the same packaging as the Servo Drive.

Regarding the clutch mechanism cover screws, which were not tightened, the absence of the braking wire and the cable keepers and their fastening elements, which were not in the intended place, it was noted that this occurred during a partial disassembly, previously performed at the BEA facilities.

The information obtained from the organization responsible for maintaining the Servo Drive was that, after a component repair or overhaul, the cable keepers were sent uninstalled, in a package attached to the component. Thus, cable keepers were installed on Servo Drive by the maintenance organization responsible for their application on the aircraft.

During the service life of the Servo Drive, there was no preventive maintenance task to check for existence or to monitor the wear on the cable keepers.

During the preliminary tests of electrical continuity and insulation, of the servo engine, of the rotation circuit and of the clutch, the following results were obtained:

- engine circuit: pins S and T - 31.7 Ohms;
- rotation circuit: pins M and N - 44.9 Ohms;
- clutch circuit: pins L and J - 50.4 Ohms;
- opening of the clutch, de-energized: 0.015 ”(the minimum expected was 0.009”);
- engine rotation counterclockwise: starting at 15 volts and 0.44 amperes (expected 0.11 amperes or less);
- clockwise rotation of the engine: starting with 10 volts and 0.45 amps (expected 0.11 amps or less);
- clutch engagement: 10.5 volts (expected 21 volts); and
- engine noise: it was found that the engine made more noise than expected in both directions of rotation and that the noise seemed to worsen with increasing speed.

Subsequently, during the execution of the complete Acceptance Test Protocol, carried out as established in the CMM, the following findings were made:

- the component failed the dielectric test with 0.7 Mega Ohms;
- the Servo Drive was not able to reach the expected torque for the applied voltage values;
- it was not possible to perform part of the tests because the electric engine needed more than the expected 6 volts to start spinning;
- with the electric engine set disconnected from the other Servo Drive mechanisms, it was found that it (electric engine) could be turned manually, but with greater resistance than expected;
- higher voltage and current values than those typically required were necessary to run the engine;
- the engine rotated with an audible noise and it was difficult to rotate it with your fingers;
- with the electric engine disconnected from the assembly, the other gears of the Servo Drive were free to rotate smoothly manually; and
- the electric engine was the cause of the Servo Drive failure in the dielectric test.

It is worth mentioning that there was no torque parameter or level of resistance to the rotational movement, to be measured on the electric engine shaft, to assess its compromise when disconnected from the other gears of the Servo Drive.

PN S2211001100000 cables were components subjected to periodic inspections, designed to keep them in service or reject them.

The AMM established criteria for wear, increase in diameter, broken wires and visible corrosion for the rejection of these components.

The Maintenance Review Board Report and Maintenance Planning Document, issued by the aircraft manufacturer, provided guidance on deadlines and maintenance criteria and established that the servo actuators and control cables of the autopilot system should be inspected at intervals of one year (Inspection 1YE).

The tension of the cables of the aileron mechanical control system, according to the referred documents, should be checked every 10,000 hours of operation (Inspection 2C).

Regarding scheduled maintenance and scheduled checks for the aircraft systems related to the Servo Drive and the control cables connected to them, the search in the documentation for these tasks showed that all the scheduled records had been performed.

1.17 Organizational and management information.

Nil.

1.18 Operational information.

The aircraft was carrying four crewmembers (two pilots and two flight attendants) and 55 passengers and had approximately 2,000 kg of fuel. At SBRP takeoff, the plane had a total weight of 20,864kg and operated within the weight and balance limits.

The route was completed according to the flight plan, in FL170, with a total flight time of 55 minutes.

During the descent, crossing 5.500ft to intercept the locator of the ILS T procedure for runway 09R (Figure 23), in approach to the ISKUL point (Intermediate Fix), the AILERON MISTRIM message was lit.

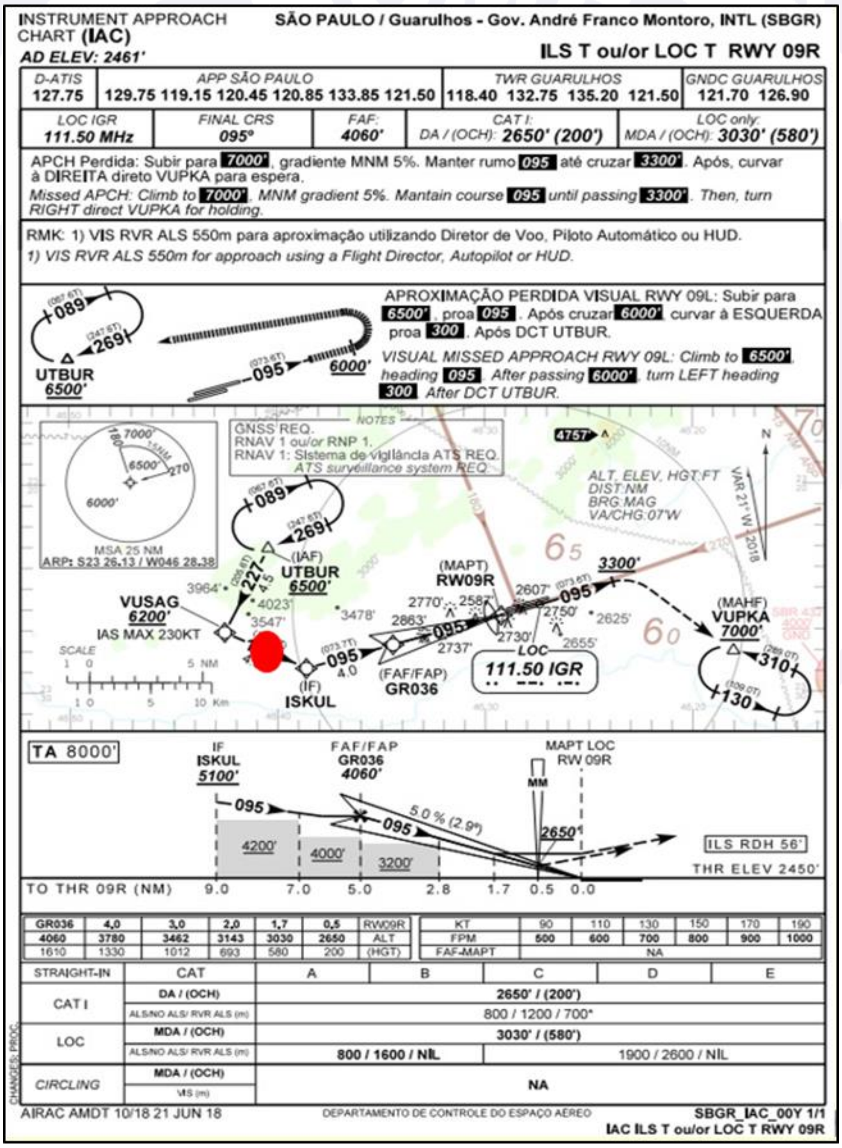

Figure 23 - Approximate point of the AILERON MISTRIM alarm (in red), during the execution of the ILS T RWY 09R procedure.

The aircraft tended to turn left when intercepting the locator with the autopilot engaged. The crew performed the procedures provided for the condition of AILERON MISTRIM - Abnormal Procedures, of the Flight Crew Operations Manual, Rev. 1.0, from January 2018, as shown in Figure 24.

AILERON MISTRIM

AILERON MISTRIM (ADU MESSAGE)

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ALL

AILERON MISTRIM (ADU MESSAGE)

► CONTROL COLUMN & WHEEL...HOLD FIRMLY
► AP .... DISENGAGE
► LATERAL TRIMS...ADJUST

- **When lateral trims adjusted**

AP CAN BE REENGAGED

Additional Information

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ALL

Ailerons forces are affected by external conditions such as:

- Prolonged exposure to severe icing
- Deicing/anti icing holdover time exceeded

Figure 24 - AILERON MISTRIM - Abnormal procedures, of the Flight Crew Operations Manual, Rev. 1.0, from January 2018.

Although the PA was uncoupled, the tendency to turn to the left continued throughout the procedure. This condition resulted in a go around since the final was out of phase with the locator axis.

As a result, the crew performed a go-around procedure and made a visual traffic circuit, with turns on the right, without the aid of the autopilot. Landing was carried out on the SBGR RWY 09R.

According to the crewmembers, the control of the steering wheel to the left was limited and it was not possible to use it in its maximum amplitude.

1.19 Additional information.

The MSG-3 Operator / Manufacturer Scheduled Maintenance Development was a document developed by the Airlines For America (A4A), formerly the Air Transport Association or ATA. It aimed to present a methodology to be used for the development of tasks and scheduled maintenance intervals acceptable to regulatory authorities, operators and manufacturers of aircraft systems and components.

The MSG-3 was widely used to develop maintenance requirements for modern commercial aircraft, which were published as a MRBR.

The so-called ISC, composed of representatives from operators, manufacturers and regulatory agencies, appointed specialized maintenance working groups that performed detailed analyzes using the MSG-3 methodology. These groups developed an appropriate series of maintenance tasks for approval by the ISC.

In turn, the MRB was comprised of regulatory personnel assigned to monitor development and finally approve the Initial Maintenance Program. The ISC sent the complete schedule and, once approved, the MRB published it.

Among other aspects, the methodology contained in the MSG-3 established a classification of failures in effect categories.

Based on the MSG-3 methodology, the context was observed in order to verify if there was a direct relationship between the failures and an adverse effect on operational safety. If not, the next step was to check if there was a direct relation between failures and an adverse effect on operational capacity (operational impact).

Failure categories were established according to their potential effect: Evident Safety (Category 5), Evident Operational (Category 6), Evident Economic (Category 7), Hidden Safety (Category 8) or Hidden Non-Safety (Category 9).

1.20 Useful or effective investigation techniques.

Nil.

2. ANALYSIS.

It was a regular passenger flight and, until the descent to land on SBGR, everything went smoothly.

However, during the interception of the runway locator 09R (ISKUL point), when the plane crossed approximately 5.500ft descending, the AILERON MISTRIM alarm was activated, after which the aircraft started to present a difficulty in its control of roll.

The crew performed the procedures prevised in the aircraft's checklist (Abnormal Procedures). The failure resulted in a final being far from the locator axis and resulted in a go around to make a traffic circuit for landing in visual conditions, which allowed a safe landing, without major abnormalities.

Initial surveys, conducted the day after the occurrence, showed that the movement of the control wheel was restricted.

Subsequently, the verification of the aileron control system allowed to verify that one of the PN S2211001100000 control cables, which connected the autopilot servo actuator to the aileron control bellcranks (Quadrant Assy), was broken and blocked the rotating mechanism, called capstan, in which it was rolled up, preventing it from turning.

Since, after removing the broken control cable, the capstan started to rotate freely, it was concluded that its locking occurred due to the cable becoming entangled in the drum, after breaking, and that this was the root cause of the restriction in the ailerons commands experienced by the pilots.

During these initial examinations, it was also found that the electric engine shaft that activated the Servo Drive set had some resistance to manual rotation, suggesting that there was an abnormal condition in its operation.

In addition, measurements of the distances between the four cable keepers and the drum showed that three of them were further away from the capstan than recommended in the CMM and that they had regions of wear, probably due to the friction between them and the control cables.

Regarding the discrepancies observed in relation to the cable keepers (distances between them and the drum / wear), although the space between them and the capstan was not the one recommended to guarantee the permanence of the cables in their respective runways, especially in the event of a significant fall of tension, it was not possible to relate them to the breaking of the control cable or to the fact that it blocked the movement of the drum of the Servo Drive.

On the other hand, the tests carried out on the failed control cable showed that there was a fatigue mechanism in several regions where the wires were broken.

The signs of wear, plastic deformation and ductile fractures were considered secondary or subsequent to the event of rupture of the first wires of the cable weft, since the report issued by the AMR concluded that it failed due to a process of fatigue.

The corrosion found on the surface of the cable could be a consequence of the time elapsed from the breaking event until the moment of analysis in the laboratory.

The manufacturer's maintenance manuals provided that checks of the condition of the PN S2211001100000 control cables were carried out annually. These inspections were designed to keep them in service or reject them.

Thus, there were no established limits for its replacement in terms of flight hours, operating cycles, or even the time elapsed since its manufacture or installation on the aircraft.

The recommended inspections included checking the surface condition of the cables, such as broken wires, wear and corrosion.

Considering that all records related to scheduled maintenance and scheduled checks for the aircraft systems related to the Servo Drives and the control cables connected to them had been carried out, it was concluded that, until the moment of the occurrence, the maintenance action as applied did not allow to detect the degradation of the cable before the rupture.

Thus, the investigation found that the inspections programmed by the manufacturer, which were the means it established for checking the condition of the control cables and for their maintenance in service were not sufficient to detect the fatigue process on the material that resulted in this incident.

Examinations subsequently conducted on the Servo Drive's electric engine showed that it did not have normal operating conditions. During the various measurements, both the preliminary tests of electrical continuity and insulation and the complete Acceptance Test Protocol, parameters different from those required by the CMM were observed.

Thus, it is concluded that, at the time of these tests, the Servo Drive was in a failure condition, according to the criteria established in its test manual, notably with regard to the effort required for it to rotate.

Regarding such damages, it is possible that the discrepancies observed in the operating parameters of the electric engine were caused by the locking of the Servo Drive capstan, due to the screwing of the broken cable.

In this hypothetical scenario, during the operation of the aircraft with the autopilot engaged and the fact that the autopilot was reengaged five times just after the cable was broken, the voltage applied to the electric engine by the controls coming from the autopilot, without the capstan being able to move, may have damaged its circuits, changing the insulation and operating characteristics of this component.

Considering that the circuit breaker dedicated to protecting the electrical circuit that provided voltage for the operation of the Servo Drives remained closed, it is likely that the current applied to the system has not exceeded the 7.5 amps required for its opening.

3. CONCLUSIONS.

3.1 Facts.

a) the pilots had valid CMAs;

b) the pilots had valid AT47 aircraft type Rating (which included the ATR-72-212A model) and IFRA Ratings;

c) the pilots were qualified and had experience in the kind of flight;

d) the aircraft had valid CA;

e) the aircraft was within the weight and balance limits;

f) the technical maintenance records were updated;

g) the weather conditions were favorable for the flight;

h) there was a tendency for the aircraft to continue the left turn, when intercepting the ILS;

i) the AILERON MISTRIM alarm was activated when approaching for landing;

j) the crew performed the procedures for the Abnormal Procedures AILERON MISTRIM alarm;

k) the crewmembers performed a go-around procedure on the first approach for landing, due to the lateral gap in relation to the locator's course and performed a visual traffic circuit for landing;

l) the landing was carried out successfully, without major problems;

m) the PN S2211001100000 control cable broke, which connected the autopilot servo actuator to the aileron command bellcrank;

n) the broken cable got entangled in the drum of the autopilot servo actuator and, even with the PA disengaged, prevented it from turning, which resulted in a restriction of movement in the aileron control;

o) through the tests carried out on the broken control cable, it was found that there was an ongoing fatigue process and this was the triggering factor for its failure;

p) the report issued by the AMR also stated that plastic deformations and oxidation probably occurred after the cable has broken;

q) the preventive maintenance actions prevised for the PN S2211001100000 control cables included periodic inspections, designed to keep them in service or reject them;

r) the Aircraft Maintenance Manual (AMM) established criteria for wear, increase in diameter, broken wires and visible corrosion for the rejection of these components;

s) there were no limits established for the replacement of PN S2211001100000 control cables in terms of flight hours, operating cycles, or even the time elapsed since their manufacture or installation on the aircraft;

t) the aircraft had minor damage; and

u) all occupants left unharmed.

3.2 Contributing factors.

- **Project – undetermined.**

Considering that all records related to scheduled maintenance and scheduled checks for the aircraft systems pertinent to the Servo Drive and the control cables connected to them had been carried out, it was concluded that, until the moment of the occurrence, the planned maintenance as executed could not reduce the possibility of an event of that nature occurring

Thus, since the mechanism that led to the failure of the PP-PTQ aircraft's control cable was only identified through examinations with optical and electronic equipment (Stereoscope and SEM), it is possible that the inspections programmed by the manufacturer were not the most appropriate method for determining whether these components remain in service or not.

4. SAFETY RECOMMENDATION.

A proposal of an accident investigation authority based on information derived from an investigation, made with the intention of preventing accidents or incidents and which in no case has the purpose of creating a presumption of blame or liability for an accident or incident. In

addition to safety recommendations arising from accident and incident investigations, safety recommendations may result from diverse sources, including safety studies.

In consonance with the Law n°7565/1986, recommendations are made solely for the benefit of the air activity operational safety, and shall be treated as established in the NSCA 3-13 "Protocols for the Investigation of Civil Aviation Aeronautical Occurrences conducted by the Brazilian State".

Recommendations issued prior to the publication of this report:

To the Brazil's National Civil Aviation Agency (ANAC):

IG-048/CENIPA/2017 - 01 **Issued on 01/31/2018**

Interact with the aircraft manufacturer (ATR), in order to review the scheduled maintenance procedures for the inspection of Part Number S2211001100000 control cables connected to Servo Drive Part Number 7002260-722 and installed on ATR-72 aircraft -212A, concerning to ensure the adequacy and robustness necessary to identify deterioration processes due to material fatigue.

IG-048/CENIPA/2017 - 02 **Issued on 01/31/2018**

Interact with the aircraft manufacturer, in order to verify the need to assign a "life limit" to Part Number S2211001100000 control cables that are connected to Servo Drive Part Number 7002260-722 and installed on ATR-72-212A aircraft, regarding flight hours and / or time elapsed since installation.

Recommendations issued at the publication of this report:

To the Brazil's National Civil Aviation Agency (ANAC):

IG-048/CENIPA/2017 - 03 **Issued on 07/08/2021**

Work with the ATR - GIE *Avions de Transport Régional*, with the purpose of that company considers the need of evaluating the batch of control cables installed in the Servo Drive of the MSN 874 aircraft at the time of this occurrence, and to subject them to tests, to ensure that the preventive maintenance actions in force guarantee an acceptable level of safety for their permanence in service.

5. CORRECTIVE OR PREVENTATIVE ACTION ALREADY TAKEN.

In response to Safety Recommendation IG-048 / CENIPA / 2017 - 01, ATR informed the ANAC that the annual inspection task JIC 22-16-00 DVI-10000-1 has been updated, in conjunction with chapter 20 of standard practices of the AMM, to assist operators in identifying damaged cables.

In response to Safety Recommendation IG-048 / CENIPA / 2017 - 02, ATR informed the ANAC that a proposal for the disposal of cables at each 2C check was taken to the Industrial Steering Committee (ISC) for the ATR-72 fleet and refused by the committee, considering that the failure was categorized as Category 6, which is evident and with operational impact.

Thus, considering the number of reports that the manufacturer had and the operational impact associated with the possible replacement of the cable, it was decided not to create a new task to dispose of this component, as this could introduce a new unnecessary problem for operators.

The ISC decision was shared and accepted by the MRB Chairperson of the EASA, which is the primary authority for this program.

In this context, ATR decided to launch a redesigned cable

According to ATR, in service experience shows 16 events over approximately 26 million flight cycles of AP roll cable failure amongst ATR 72-212A history. The current definition of the cable is 7x7. The AP actuator capstan diameter increases the sensitivity to internal cable friction. The definition of a cable with the same external dimensions but having a higher number of wires will decrease the relative movement of the wires during the actuation of the cable hence will reduces the internal friction as per ARP 5770. ATR has launched the development of a modification to replace the cable 7x7 by a cable 7x19.

On july 8th, 2021.